REMARKS

The Advisory Action of March 21, 2011 has been received and carefully considered. A request for continued examination is hereby submitted so that the Examiner can enter and consider the response and Declaration submitted on March 7, 2011 as well as the current response. Applicant respectfully disagrees with the obviousness rejection under 35 U.S.C. 103. All claims are now present for examination and favorable reconsideration is respectfully requested in view of the previous amendments and the following comments and evidence.

<u>REJECTIONS UNDER 35 U.S.C. §103</u>:

Claims 1 and 4 – 17 have been rejected under 35 U.S.C. §103 as allegedly being unpatentable over Tubel (US Pat. Appl. Pub. No. 2003/0094281 A1) in view of Varasi (US 5,493,390).

Applicant traverses the rejection and respectfully submits that the embodiments of present-claimed invention are not obvious over the cited prior art references. Pending Claim 1 is directed towards a railway monitoring system, comprising:

> an optical fiber, wherein a first part of the fiber is attachable to one of a pair of tracks of a rail, and wherein a characteristic of the first part of the fiber is variable in correspondence to variance of a characteristic of said one track where the first part of fiber is attached;
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> an optical signal emitter connected to the fiber for emitting an optical signal into the fiber, wherein the fiber generates at least a first altered optical signal, which contains information relating to the variance of the characteristic of the part of the fiber; and
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> an optical signal analyzer connected to the fiber for receiving and analyzing the first altered optical signal so as to ascertain the variance of said characteristic of said one track based upon the information contained in the first altered optical signal;
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> wherein both the emitter and the analyzer are connected to an end of the fiber, and wherein the first altered optical signal is a signal reflected by the fiber towards said end; and
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> wherein the first part of the fiber includes a first Bragg grating created therein for generating the first reflected optical signal, wherein a characteristic of the first Bragg

grating is variable in correspondence to the variance of said characteristic of said one track, and wherein the first reflected optical signal contains information relating to the variance of the characteristic of the first Bragg grating.

Tubel (U.S. Patent Application Publication US 2003/0094281 A1) discloses a method and system for monitoring smart structures utilizing distributed optical sensors, and specifically discloses in Fig. 5 an exemplary configuration for monitoring the process of construction of a highway or rail system. The configuration includes a distributed fiber sensing device 30 embedded in the structure or placed on the outside of the structure, e.g. a rail, to monitor the structure and help assure compliance with manufacturing requirements. Tubel states that the disclosed rail system may be used to determine a train's location in the system monitored by distributed fiber sensing device because the train will cause a strain in rails as well as vibration that can be detected by distributed fiber sensing device.

The Examiner alleges that the Tubel differs from the claimed invention in that Tubel does not specifically disclose that the first part of the fiber includes a first Bragg grating created therein for generating the first reflected optical signal, wherein a characteristic of the first Bragg grating is variable in correspondence to the variance of said characteristic of said one track, and wherein the first reflected optical signal contains information relating to the variance of the characteristic of the first Bragg grating. The Examiner further alleges that Tubel discloses that the fiber sensor can be a Bragg grating (at paragraph [0077]), and that Varasi also discloses the above distinguishing feature.

Applicant respectfully traverses the Examiner's rejections and submits that the currently claimed invention is not obvious over the cited references, on the basis that there is no teaching, suggestion or motivation to combine the cited references.

<u>Components of a railway monitoring system</u>

Professor Sui Lau HO, an inventor of the present invention, stated the requirements for a railway monitoring and control system in a Declaration under 37 CFR 1.132 (copy enclosed, see Sections B, C & D). A summary is presented below.

The definition of railway monitoring is understood to include railway signaling which "monitors" the trains in real-time. In this respect, railway monitoring systems exist in almost all railway networks. This is predominantly for safety in order to prevent malfunction and, in particular, collisions of trains. Railway monitoring systems also allow the controlling and scheduling of trains within a railway network.

Reliable up to date information regarding the location of trains is of paramount importance for safety within a railway network. Sadly failure of signaling systems has resulted in loss of human life due to train collisions on many occasions, as well as significant economic loss due to damage, as well as disruptions to transportation in railway networks.

A railway monitoring system, in its most general form, comprises a network of sensors located at various locations within a railway network, which provide information back to a central control station or a sub-control station such that the operation conditions, including the presence of a train at a particular location of a railway network, is ascertained.

Railway sensors are generally of a non-contact type sensor, which detects when rolling stock of a train passes a particular location in a train network.

Included in railway monitoring systems are CTS (code track equipment set) units, which are positioned at remote locations within a railway network, in the vicinity of sensors. Signals indicative of the presence of railway rolling stock at a sensor is received by a CTS unit, where the signal is locally processed.

CTS units may include processing type equipment, hardware and software, specific to the respective sensors used at the location. The CTS units require electricity which may be obtained from dedicated rail-side electrical supply systems, a local electricity grid or, in some remote locations, by independent local power supply.

Signals processed at a CTS are received into a railway control network, which transfers signals to central and/or local control stations. The signals are then processed centrally at the control station in order to extract data recording where rolling stock is located and at what time. Signal transmission may be by way of telegraph wire, radio-frequency communication (RF), or a combination thereof.

There exist numerous variations and specific hardware and software for railway monitoring systems. Systems are routinely upgraded for enhanced control, efficiency and safety. Regardless of the specific configuration, railway monitoring networks include at least the following general features:

(i) a plurality of sensors

(ii) local CTS units for receiving and processing of signals received from sensors

(iii) power supply system for powering of sensors and/or CTS units

(iv) railway control network for transmission of signals from CTS units to a central/local control station

Conventional systems: safety and problems

These considerations are addressed in Section E of Professor Ho's Declaration and are outlined again below. Failure at any part of a railway monitoring system, or interference and corruption of signals within a system can have serious consequences. For this reason, reliability of the system is paramount.

Further, due to environmental considerations, railway monitoring systems must be reliable, robust, and require minimal maintenance for extended periods of operation.

Failure of a railway monitoring may be caused by:

(a) physical failure of sensors;

(b) failure or interference with signals received from sensors;

(c) failure of components of CTS units;

(d) failure of power supply to CTS units and sensors;

(e) failure of transmission of signals through a railway monitoring network; or

(f) failure of power supply to transmission devices of a railway monitoring network.

In addition to the physical interference arising from natural environmental conditions, railway monitoring systems may also experience failure due to the following:

(i) loss of power to a CTS unit;

(ii) loss of power to a local relay transmission station;

(iii) electromagnetic interference (EMI) from the railway network including:

a. EMI from overhead power cables inducing current and voltage in signal transmission lines from sensors to CTS units and in signal transmission lines CTS units to a monitoring network and within sensors themselves, which may be in order of 600V, and which poses serious safety risks to workers and technicians;

b. EMI interference from current through rails, which may be of the order of 100A, which may cause interference and induce current and voltage in signal transmission lines from sensors to CTS units and in signal transmission lines CTS units to a monitoring network, as well as within sensors themselves; or

c. EMI interference from rolling stock, again which may cause interference and induce current and voltage in signal transmission lines from sensors to CTS units and in signal transmission lines CTS units to a monitoring network and in sensors themselves; All of these forms of EMI may affect the integrity of signals within a railway monitoring network, thus compromising the integrity and safety of a railway network; or

(iv) EMI due to thunderstorm activity, which can also cause failure within a monitoring network. Thunderstorm activity can result in the shutdown of a

large portion of a railway network for safety reasons, which must then be "re-set" by sequentially directing trains from a control station to commence motion at slow speeds and confirm their position or location within a railway network. Such a 'start-up" after a shut-down requires cautious re-initiation after problematic thunderstorm activity has ceased, for safety reasons. Shut down of a railway network also causes negative economic and social impact.

The Person of Ordinary Skills in The Art

The present invention relates to the field of monitoring railway rolling stock within a railway network. As such, the person skilled in the art is a railway engineer with experience in the field of network monitoring systems. Mr. Kang Kuen Lee has experiences in the railway industry as stated in his Declaration under 37 CFR 1.132 (copy enclosed). It is clear from the details given in paragraphs 1 to 8 of this Declaration that Mr. Lee can be considered "a person skilled in the art", for the purposes of this present invention.

As stated above and by Professor Ho in paragraphs 16 to 26 of his Declaration, there are considerable safety and reliability requirements for any development of a railway monitoring network. Thus, a new component must not only exhibit a marked improvement in performance over a conventional part, it must also match it in terms of safety, reliability and ability to interface with the existing network system. For this reason, innovation is very limited. As illustrated by Professor Ho in paragraphs 27–32 of his Declaration, developments are made to individual components such as improved sensors, incorporation of digital technology to signal processing, once that itself was a mature field, or to improved insulation.

The historical development outlined by Professor Ho implies that innovation in the field of railway monitoring systems is made to improve existing components, and not

to develop a different system. Mr. Lee states that: "railway engineering is of a conservative nature". This is, in Mr. Lee's opinion, "due to the onerous requirements in respect of primarily safety to passengers and property". The result is, among other things, that "experts in the field of railway stress analysis and investigation have been engaged and worked on KCR projects for nearly 30 years, all of which utilized known, accepted and standardized strain gauge techniques for analysis in conjunction with theoretical models". That is, conventional strain gauges, based on electromagnetic technology, remain the norm.

In Mr. Lee's experience: "when providing improvements and upgrades to a railway monitoring system, railway engineers will implement technology ... which they believe ... satisfies the onerous reliability and safety factors and which can be readily verifiable against existing data and knowledge, due to the extreme consequences of failure of a portion of a railway monitoring system." With the result, "significant changes within the field are met with skepticism, and railway engineers will work within or close to the known confines of the technology, and undertake significant verification and auditing before even changes or modifications are made to a portion of a railway monitoring system".

The statements of Mr. Lee in combination with the historical development detailed by Professor Ho and verified by Mr. Lee, all clearly indicate a prejudice in the field against the introduction of new technologies. The existing system, based on electromagnetic sensors, interfacing with an electrically-powered CTS for onward transmission to a central control has been around for some 30 years.

The present invention

It is against the background of the above-described person skilled in the art that the present invention must be viewed. The present invention, as claimed, is a railway

monitoring system suitable for monitoring rolling stock activity and positions at remote locations.

The system of the claimed invention utilizes a plurality of sensors, the signals from which can be directly detected using a single optical signal analyzer. The analyzer allows the position of strain to be identified from a distance many tens of kilometers from the location of the sensors. That is, signals generated by the sensors are neither locally detected nor locally processed. This single detection means may therefore be used in place of the CTS.

Without the CTS units, there is no longer any need to power them. Moreover, the sensors of the system according to the present invention are passive in nature, and are not locally powered. That is, no local power requirements remain.

The present invention overcomes many problems and shortcomings of the prior art, both conventional and as cited by the Examiner, as well as offering significant economic, reliability and maintenance advantages.

In summary, the present invention represents both a development of the prior art sensor and the prior art CTS system. Such a dramatic alternative approach to a railway monitoring system is not seen in the known prior art nor previously known by Professor Ho, or by Mr. Lee, a person skilled in the art.

No Motivation to Combine the Cited References

It is respectfully submitted that those skilled in the art would not have found it obvious to use fiber Bragg gratings to modify the Tubel's invention in order to arrive at the presently claimed invention, on the basis that there is no teaching, suggestion or motivation to combine the cited references.

It would be apparent that the main focus of the Tubel's invention is to use distributed sensors based on technologies different from fiber Bragg grating. In particular, Tubel explicitly proposes using following scattering techniques whereby stress and strain on rails may be detected, namely "Rayleigh, Brillouin, and Raman scattering

techniques" (see paragraph [0115]) to measure the railroad conditions to address the inadequacy of discrete sensors, including fiber Bragg gratings, for railroad condition measurements.

Although Tubel also vaguely stated that "other techniques used to obtain information as the light reflects as it travels in and out of fiber optic cable 20" (see paragraph [0115]), apparently those skilled in the art would not readily ascertain that fiber Bragg gratings may be used.

In this regard, the Examiner appears to have failed to establish why those skilled in the art would have been motivated to use or replace the discrete sensors 32 with fiber Bragg gratings, when the examples such as "Rayleigh, Brillouin and Raman scattering techniques" are already explicitly proposed by Tubel for railway applications.

Even though the person skilled in the art would look for other examples, they would not find it obvious to use fiber Bragg gratings to modify the Tubel's invention. For instances, Tubel states that "Reliability can be improved if no sensors 32 are deployed in rail 302, using reflected photons from the light travelling into fiber optic cable 20 instead" (see paragraph [0116]). Tubel also states that "The advantage of this latter embodiment over the use of single point or distributed downhole sensors 32 (such as the Bragg grating sensors 32 described in the aforementioned patents) is improved reliability, lower cost as well as more precise measurements".

It has to be emphasized that in railway industry, reliability is critically related to human safety and hence reliability is considered to be of utmost importance. The fact that Tubel had stated that the use of sensors based on Raman and/or Rayleight and/or Brillouin techniques is more reliable than the use of discrete sensors such as FBG sensor would definitely serve as a positive discouragement to deter railway engineers in using FBG sensors as railway engineers are most concerned about safety and hence reliability. If a more reliable alternative is being pointed out, the railway engineer will therefore not even bother look at the less reliable system which uses discrete sensors such as those using FBG sensors. This also shows that Tubel was not aware of and hence did not appreciate the full potential of Fibre Bragg grating in railway applications. Based upon these

references, it would be apparent that those skilled in the art would be taught away from using fiber Bragg grating for monitoring conditions of the railway.

Furthermore, Tubel at paragraphs [0099] and [0114] to [0116] would appear to suggest that fiber Bragg grating sensors are considered to be inferior and are not recommended:

> "[0099] In a preferred embodiment, fiber optics cables 20, 22 have no associated discrete sensors 32. Instead, the fiber optics cable itself is used to acquire the necessary information using Raman and/or Rayleigh and/or Brillouin techniques wherein reflected photons are monitored from the surface and utilized. <u>The advantage of this latter embodiment over the use of single point or distributed downhole sensors 32 (such as the Bragg grating sensors 32 described in the aforementioned patents) is improved reliability, lower cost as well as more precise measurements</u>.
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> ...
>
> [0114] Referring now to Fig. 5, the transportation industry also has requirements for intelligent structure. By way of example and not limitation, the present invention may be used for monitoring of the process of construction of a highway or rail system (shown in the figure as rail system 300). The present invention may be used to determine stress, strain, pressure, temperature, vibration and other parameters that are exerted on the structure during the construction of the structure, e.g. the road bed or rail bed 302. Distributed fiber sensing device 30 may be embedded in the structure or placed on the outside of the structure, i.e. rail 304, to monitor the structure and help assure compliance with manufacturing requirements. By way of example and not limitation, distributed fiber sensing device 30 can determine if there is a problem with the rail system that could cause the train to derail. The ability to monitor strain along the axis of a fiber optic cable 20 associated with distributed fiber sensing device 30 provides this unique capability. Further, the ability of Brillouin technology to monitor events occurring along distributed fiber sensing device 30 may provide a resolution of ten centimeters or better, thus allowing for accurate measurement of the entire length of fiber Optic cable 20 instead of discrete points in fiber optic cable 20.
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> [0115] Using rail system 302 as an example, the present invention may be used to determine a train's location in the system monitored by distributed fiber sensing device 30 because the train will cause a strain in rails 304 as well as vibration that can be detected by distributed fiber sensing device 30. Further, the present invention may be used to monitor wear of rail system 302 (or bridge or road) due to the traffic on the structure. By way of example and not limitation, the present invention can detect the stress and strain on rails 304 using distributed Rayleigh, Brillouin, or Raman scattering techniques or other techniques used to obtain information as the light reflects as it travels in and out of fiber optic cable 20. In

> this manner, distributed fiber sensing device 30 and discrete sensors 32 located throughout rail system 302 or road system may also be used to monitor other adverse conditions such as subsidence of the ground that can damage the structure. The use of distributed fiber sensing device 30 to detect and measure physical parameters such as pressure, temperature, strain, and acoustics can assure that the structure is being monitored properly.
>
> [0116] The use of distributed temperature and strain techniques related to Rayleigh, Brillouin, and Raman and other reflection and photon or phonon scattering techniques can provide a significant advantage over electric and mechanical sensors 32. By way of example and not limitation, the entire structure 302 cm be monitored using a single fiber optic cable 20 instead of deploying multiple sensors. Reliability can be improved if no sensors 32 are deployed in rail 302, using reflected photons from the light travelling into fiber optic cable 20 instead." (emphasis added)

Furthermore, when reading Tubel in which Bragg gratings are explicitly proposed in other embodiments but not in the embodiment for railway application, those skilled in the art would have taken the view that Bragg gratings may not be preferable in the railway monitoring system other than Rayleigh, Brillouin, and Raman scattering techniques as explicitly discussed and proposed. That is, although fiber Bragg grating is being mentioned in other embodiments of Tubel, Tubel has in fact positively discouraged those skilled in the art to use fiber Bragg grating for monitoring the conditions of railway infrastructure.

Moreover, even though those skilled in the art would have looked to Varasi, it would be difficult for them to ascertain whether the Bragg gratings have been dislocated unless the pre-strain technique proposed in the present invention is used, and such pre-strain technique are neither taught nor suggested by the cited references.

In this regard, it is respectfully submitted, as discussed above and in the Exhibits provided, that the prevailing practice of railway engineers in railway monitoring systems is of a conservative nature, and due to large amounts of infrastructure in existence for which the reliability and the acceptability within industry standards has over a long period of time gained acceptance, due to the onerous safety requirements which dictates high levels of reliability as well as redundancy measures.

A railway engineer, as demonstrated throughout the prior art and in relation to modern day technologies, utilizes the implementation of railway monitoring system technology and infrastructure in existence, as such equipment is interfaced within a network in a manner which has been tested over a long period of time and reliability and confidence in such a system has been established.

Upon reading of Tubel, a railway engineer would identify the system as described as being that typical, tried, tested and established in the art. Without any inference or hint in Tubel that Bragg gratings could provide any enhanced advantage in comparison with those as described with reference to the preferred embodiment, a railway engineer would unlikely be motivated to use Bragg gratings in preference to those described in relation to the embodiment of Fig. 5.

Furthermore, the Examiner appears to consider that in moving from the embodiment of Fig. 5 of Tubel to the present invention, all that is required is knowledge of the existence of fiber Bragg grating, for one skilled in the art to arrive at the present invention. In fact far more than this is required:

(i) firstly would one skilled in the art consider Tubel of any significance, given their knowledge of prevailing practices, and inherent reluctance for implementation of non-established core technologies?

(ii) even if Tubel is accepted as a starting point for further development, would one skilled in the art consider alternative optical sensors to replace those of Tubel, in view of the prohibitive costs and given that the sensors of Tubel have already shown improved resistance to EMI and lightning?

(iii) there is also the reliability issue as some railway engineers had indeed tried installing optical sensors to monitor the performance of railway systems; however many of these sensors did not survive for more than a few months before fallen out from their installed locations. Such knowledge has indeed deterred many who were contemplating to using optical sensors in demanding and harsh environments such as in the railway industry;

(iv) then consider that there could possibly be further potential benefits of optical sensors other than those explicitly disclosed in Tubel that is can more than simply improvements in EMI and lightning resistance be anticipated?

(v) finally realize that a Bragg grating offers not only an alternative to the sensor disclosed in Tubel, but potentially can be used for more significant and surprising benefits: namely, its ability to enable localization of the source of strain permits wholesale replacement of the CTS by an improved optical system?

Assuming for the sake of argument that, despite inherent prejudices to development of the field, that the stated improved resistance to EMI and lightning of the optical sensor in Tubel leads one skilled in the art to undertake further research into optical alternatives. Tubel teaches use of an optical sensor. Other fiber optic sensors are briefly referred to in Tubel at paragraphs [0077], [0099]. However, no mention as to how such gratings would be implemented within the claimed invention is made. Moreover, Bragg gratings are not included in the preferred embodiment described in Tubel and so, by implication, are only taught as probable lesser alternatives to that proposed in paragraph [0116].

Thus, even if one skilled in the art were to look to other embodiment such as that in paragraph [0077] of Tubel, or to Varasi, then would they consider Bragg gratings to provide an alternative replacement for a sensor? Given the prejudice in the field against the introduction of new technologies and the extreme conservative mindset, it would appear that a railway engineer would not find it obvious to implement Bragg gratings in the embodiment of Fig. 5 of Tubel's invention, when there is no express indication that Bragg gratings are particularly suitable to railway monitoring systems or has been tried and tested in a railway environment. In this regard, although Varasi states that the invention therein may be applicable to "ground transportation", "railway", the absence of clear examples as to how the optical sensors can be implemented in railway systems raises doubt as to why those skilled in the art would be motivated or find it obvious to replace the optical sensors of Fig. 5 of Tubel with Bragg gratings.

It is respectfully submitted that a person skilled in the art would not be motivated, in view of neither Tubel nor any other cited references, to consider:

(a) removing the infrastructure of a railway monitoring system including CTS units;

(b) removing the transmission lines from sensors to CTS units, the requirement for power at the remote locations;

(c) removing of multiple detection technology as well as the associated sensor communication network; and

(d) replace this well-established and accepted infrastructure with a single fiber having a plurality of strain sensors formed therein, the instance of strain which could be individually identified in relation to particular sensors by remotely located detection and powering means whilst also overcoming significant problems within the technical field of EMI, thunderstorm activity interference, and stray EMI causing potentially lethal voltages within communication transmission lines.

In view of the above, Applicant submits that Claims 1 and 4 – 17 would not have been obvious to those skilled in the art.

Therefore, the rejection under 35 U.S.C. §103 has been overcome. Accordingly, withdrawal of the rejections under 35 U.S.C. §103 is respectfully requested.

Having overcome all outstanding grounds of rejection, the application is now in condition for allowance, and prompt action toward that end is respectfully solicited.

Respectfully submitted,

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Enclosures:

Declaration under 37 CFR §1.132 by Siu Lau HO
Declaration under 37 CFR §1.132 by Kang Kuen LEE